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American Society for Quality — Electronics & Comm. Div.
American Society for Quality — Reliability Division
Institute of Electrical & Electronics Engrs — Reliability Society
Institute of Environmental Sciences and Technology
Institute of Industrial Engineers
Society of Automative Engineers
Society Of Logistics Engineers
Society of Reliability Engineers
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Xerox Corp.

An Invitation To:

RAMS

The International Symposium on Product Quality & Integrity

Web: http://www.rams.org

OUR

January 23 - 26, 2006
Newport Beach Marriott
900 Newport Center Drive
Newport Beach, CA 92660 USA
1-949-640-4000
1-800-228-9290
Fax 1-949-640-5055

IMPROVING PRODUCTS AND PROCESSES THROUGH EDUCATION

General Chair's Message

Ron M. Adib

Welcome to the 52nd Annual Reliability and Maintainability Symposium (RAMS) – The International Symposium on Product Quality and Integrity. This year's topic, "The Role of Reliability and Maintainability in Managing Risk," generated great interest and the Program Committee designed an excellent program to meet the theme. You have many opportunities to benefit from this year's program whether you are a long time practitioner or new to the assurance sciences. In addition to 5 panel sessions, there are 21 tutorials and 26 paper sessions with over 120 papers. This year RAMS for the first time offers a program with 5 tracks on Tuesday and Wednesday.

RAMS is the premier forum in which R&M professionals share their experience, knowledge, and vision for the future. Learn how other organizations meet the challenges of "Managing Risk" and increasing demands for more reliable, more maintainable, more supportable, and safer products. Gain fresh insights from colleagues, industry and government leaders, and academia on a broad range of processes, tools and technologies that are necessary to assure product quality and integrity. Benefit from the successes and lessons learned by others as you join us in this event.

I encourage you to organize your week according to your particular interests and the many excellent tutorials, paper and panel sessions, and exhibits offered in the program. The tutorials qualify for Continuing Education Unit (CEU) credit and are free with conference registration. You also have an opportunity to take the American Society for Quality (ASQ) Certified Reliability Engineer and Six Sigma Black Belt examinations. As part of your registration, you are also admitted to the RAMS Exhibition where you may examine an outstanding trade show.

On behalf of the 2006 RAMS Management Committee, Board of Directors, Advisory Board, Sponsors and Exhibitors, I invite you to participate fully in this 52nd anniversary event and enjoy a week of learning and new professional relationships.

Ron M. Adib
2006 RAMS General Chair
(chair@rams.org)

The Management Committee and Board of Directors gratefully acknowledge our Corporate Sponsors.

Diamond Level

Relex Software Corporation

Gold Level

The Omnicon Group, Inc.

Plan now to present a paper, tutorial or to attend the Year 2007 RAMS. For more information, visit our Web site at: http://www.rams.org.

Registration Information

Go to www.RAMS.org to register

For RAMS 2006, all registration options will be handled through the RAMS web site. Please see page 27 for all the details.
Registration rates are:

	Registration Fees	On-Line Discount	Express On-site
*	Members of AIAA, ASQ, IEEE, IEST, IIE, SAE, SOLE, SRE, SSS	$700	$850
*	Nonmembers	$800	$950
†	Student *(Full Time - Student ID required)*	$60	$60
†	One day registration	n/a	$500

See below for multiple registration discounts

* Includes Banquet, Proceedings, Tutorial Notes, and all paper, panel and tutorial sessions.
† Includes Proceedings, Tutorial Notes, and all paper, panel and tutorial sessions.

NOTICE — Sunday, January 22, 2006 Symposium Registration
Newport Beach Marriott • Pacific Registration Desk • 3:30 PM to 6:00 PM
Avoid the Monday Morning Rush!

Discount for Multiple Registrations

RAMS offers a 33% discount for multiple On-Line Discount Registrations from the same organization. If you register six or more simultaneously the Member Rate is $467 and the Non-Member Rate is $533. You get six RAMS registrations for the price of four! Please contact Raymond Sears (contact information on the RAMS website and listed on page 27) for further information and to arrange for online registration. RAMS also offers a corporate registration for companies wishing to send multiple attendees at different times. Please contact Raymond Sears as described above for more information.

Special Travel Rates

Special discounted airfares for the 2006 Reliability & Maintainability Symposium in Newport Beach, CA on January 23-26, 2006 have been negotiated by IEEE Global Travel Services. Please see page 27 of this Program for additional details on rates and special codes. Travel arrangements using the negotiated air carriers or the carriers of your choice can be made through IEEE Global Travel Services by calling between the hours of 8:30 a.m. and 5:00 p.m. EST. Monday through Friday. Within the US and Canada, call +1 (800) TRY-IEEE, (+1-800-879-4333); and outside of the US and Canada, call +1 (732) 562-8815. Or, you may visit their on-line travel service web site at *www.ieeetravelonline.org.* This secure site offers simple and convenient service through which you can search, reserve, and ticket your travel anytime, anywhere.

Hotel Reservations

A block of rooms has been reserved at the Newport Beach Marriott. Request the International Symposium on Product Quality and Reliability or R&M Symposium (RAMS) rate when calling or writing. A limited number of government rate rooms will be available. Hotel reservations must be requested before January 10, 2006. Reservations must be guaranteed by deposit or credit card when making the reservation. The hotel accepts most major credit cards. Deposits are refundable if cancellation is received by the hotel before 6:00 PM on the day of arrival. Arrangements have been made at alternative hotels in the Newport Beach area in the case of over-booking at the Newport Beach Marriott. Rate and availability of the alternative hotels may be different than the Newport Beach Marriott. In the case of over-booking, reservations will automatically be assigned to the next closest alternate hotel. Please call the Newport Beach Marriott for hotel confirmation and information.

RAMS Exhibition

Every exhibitor has been carefully selected with improved reliability, maintainability, quality, and productivity in mind. All exhibits will be located in the Newport Coast Ballroom of the Newport Beach Marriott. Coffee breaks will be held in the exhibit area. The Exhibition is a valuable component of the *R&M Symposium* as it provides information on products and services which can help you do your job more efficiently. Even if you plan to attend every technical session, there will still be plenty of time to visit the exhibits between sessions and during lunch breaks. The Exhibition is scheduled to be open at the following times:

Monday, January 23, 5:00 PM — 7:00 PM
Tuesday, January 24, 9:00 AM — 5:00 PM
Wednesday, January 25, 9:00 AM — 4:00 PM

2006 Exhibition Space Still Available!

At press time, there were still a few booths available in the exhibit area for this years RAMS. Contact: RAMS EXHIBITION MANAGER; David F. Barber, Jr.; Scien-Tech Associates, Inc., P.O. Box 2097, Banner Elk, NC 28604-2097 USA at 1-828-898-6375, email: dbarbsta@aol.com or by FAX at 1-828-898-6379. David can also provide information on the Year 2007 RAMS Exhibition.

2006 RAMS Exhibitors as of 11 Oct

University of Maryland-Reliability Engineering
Ops A La Carte
University of Illinois-Technology Management
PredictionProbe, Inc.
Clockwork Solutions
Fulton Findings
The Omnicon Group, Inc.
Relex Software Corporation
RELIASS
ReliaSoft Corporation

Spouses' Hospitality Suite

The Spouses' Hospitality Suite is available for an informal gathering. Information will be provided regarding tour information, shopping, dining, and places of interest in the Newport Beach area. The Spouses' Hospitality Suite, located in Diamond Cove Room, will be open from 7:30 AM through 5:00 PM Monday through Thursday. Coffee, tea and danish will be provided at 8:00 AM each day. On Monday and Tuesday mornings from 8:00 AM until 10:00 AM, we will discuss the many activities available in Newport Beach and the surrounding area. The suite affords the opportunity for spouses to get together with one another to plan their day. Please stop by; meet old friends and make some new ones. Newport Beach and the Los Angeles area is rich in attractions and things to do.

IEEE Continuing Education Units (CEUs)

You can earn CEUs by attending our Tutorials and Workshops (0.1 CEU per hour). Simply use a CEU completion form included with your *Tutorial Notes*. Complete the form according to the instructions, and return it to the registration desk at the conclusion of the Symposium. Your CEU certificate will be e-mailed to you. The IEEE is an Authorized CEU Provider of the International Association for Continuing Education and Training. IACET Provider # 1255

Job Posting Board

This year the *Symposium* is sponsoring a job posting board on which openings in the assurance disciplines can be posted. ANY business interested in describing its employment opportunities to the world's premier gathering of assurance professionals is asked to contact Raymond Sears at 1-603-863-2832 or by email: r.w.sears@ieee.org. The bulletin board will be made available to all *Symposium* attendees. This is an extraordinary opportunity to get your employment message out!

Emergency Information

A Message Center will be provided for the convenience of *Symposium* attendees. Messages for attendees may be left between 8:00 AM and 5:00 PM during the *Symposium* by dialing **1-949-640-4000** and asking for the *RAMS Symposium Message Center*. All messages will be posted at the Message Center located in the RAMS Registration area.

ASQ Certified Reliability Engineer and Six Sigma Black Belt Examinations

Special arrangements have been made with the American Society for Quality (ASQ) for attendees who so desire to take the ASQ CRE or Six Sigma examinations while at the *Symposium*. These 4 hour examinations will be held on Thursday morning. On Tuesday, a 4 hour CRE Review workshop session will be held for the benefit of those who plan to take the CRE examinations or are thinking about taking it some time in the future, or are just curious. Advance registration will guarantee a seat. Information about exam fees, registration and professional prerequisites for this certification exam are available at the RAMS WEB site or by calling ASQ at 1-800-248-1946. Ask for customer service. The exam is open book. Pocket calculators without programmable memories are allowed. Registration for the CRE exam will be accepted up to Wednesday Noon at the Symposium. Come to the RAMS Registration Desk to sign up for the CRE exam. There will be no on-site registration for the Certified Six Sigma Black Belt exam due to affidavit validation. Refer to the RAMS website for additional information. Applications for the RAMS exams are now live and are at the following URL's:

https://secure.asq.org/cre_RAMS_cert.html for the CRE Exam
https://secure.asq.org/ssbb_RAMS_cert.html for the Six Sigma Exam.

Hotel Transportation

There is an Airport Shuttle. The shuttle is for John Wayne/Orange County Airport **ONLY**. The shuttle leaves the hotel every hour on the hour beginning at 6:00am and the last trip leaves the hotel at 10:00pm The shuttle picks up at the airport every hour on the half hour, beginning at 6:30am and the last pick-up is at 10:30pm The shuttle pick up is outside Baggage Claim and across the street to the Taxi/Hotel Shuttle Pick-Up area. Please be sure to look for the Newport Beach Marriott van as there are a number of other Marriott hotels in Orange County.

Program Matrix

	Time	Pacific Salon A/B	Pacific Salon C	Pacific Salon E/F	Pacific Salon D	Avalon
Monday	8:00 - 10:00 AM	Tutorial 1A Reliability Program Planning for Commercial Environments	Tutorial 1B Basic Reliability	Tutorial 1C Markov-Chain Modeling and Analysis	Tutorial 1D Probabilistic Methods & Statistical Methods in Reliability	
	10:15 - 12:15 PM	Tutorial 2A Six Sigma Process Improvement Opportunities		Tutorial 2C Human Reliability Analysis		
	1:15 - 2:00 PM	GENERAL CHAIR'S WELCOME AND KEYNOTE PACIFIC SALON C/D				
	2:15 - 4:45 PM	Tutorial 4A Reliability Growth Testing and Data Analysis	Tutorial 4B Software Reliability	Tutorial 4C Introduction to Repairable Systems Modeling	Workshop 4D R&M Exhibitor's Presentations & Demonstrations	
Tuesday	8:00 - 10:00 AM	Session 5A Product Verification and Validation: When is Good. Good Enough?	Tutorial 5B Planning and Performing Software FMEA	Tutorial 5C Statistical Analysis of Field Data for Repairable Systems	Session 5D Humans in the Loop: Managing Risk via Assessment and Mitigation of Human Factors	Tutorial 5E Simulation Modeling for Reliability Analysis
	10:15 - 12:15 PM	Session 6A Emerging Technologies and Trends	Session 6B Software Reliability and Testing	Tutorial 6C Reliability from Product Design Inception to Product Retirement	Workshop 6D R&M Exhibitor's Presentations & Demonstrations	Session 6E New Product Life Analysis Techniques to Optimizing Operational Reliability
	1:30 - 3:30 PM	Session 7A Reliability, Availability & Prognostics, Return on Investment	Session 7B Practical Data Analysis, Emerging Tools and Techniques	Tutorial 7C Improving Production through Reliability Using Available Information	Session 7D Meet the Reliability Faculties - Invited Session	Tutorial 7E Empirical Methods for Process and Equipment Condition Monitoring
	3:45 - 5:45 PM	Session 8A Using Key Performance Parameters (KPP) to Improve Reliability	Session 8B Innovative Planning Techniques for Reliability and Maintainabilityy	Tutorial 8C Understanding Accelerated Life Testing Analysis	Panel 8D Preventive and Predictive Maintenance - Necessary Evil or Valuable Practice	Session 8E Operational Reliability Requirements and Optimization
Wednesday	8:00 - 10:00 AM	Session 9A Accelerated Life Testing & Aging	Session 9B Innovative Approaches in Maintainability and Reliability	Tutorial 9C Weibull Analysis: Methodology, Applications, Benefits and Pitfalls	Panel 9D Logistics - Transition of Acquisition and Sustainment of Products and Services for the Department of Defense (DOD)	Session 9E 21st Century Reliability Approaches and Toolkits
	10:15 - 12:15 PM	Panel 10A SYMPOSIUM PANEL - RELIABILITY AND MAINTAINABILITY IN THE NEW FRONTIER PACIFIC SALON C/D				
	1:30 - 3:30 PM	Session 11A Accelerated Life and Accelerated Reliability Growth Testing	Panel 11B Prognostics Health Management (PHM)	Tutorial 11C OPTIMIZING MAINTENANCE AND REPLACEMENT DECISIONS	Session 11D Advances in Risk Assessment	Session 11E Innovations in Hierarchical Analysis and Modeling
	3:45 - 5:45 PM	Panel 12A Achieving R & M for the Army's Future Combat System	Session 12B Maintainability, Maintenance and Planning - Approaches to Real World Availability Improvement	Tutorial 12C Lessons Learned for Effective FMEAs	Session 12D Risk Assessment: Applications	Session 12E Innovations in Failure and Fault Analysis
	6:30 - 7:30 PM	GENERAL RECEPTION - ATTRIUM				
	7:30 - 9:30 PM	SYMPOSIUM BANQUET - GRAND PACIFIC BALLROOM				
Thursday	8:00 - 10:00 AM	Session 13A Designing Safety and Reliability into Space Systems	Session 13B Process Improvements and New Techniques in Systems Safety	Tutorial 13C Risk Management	Session 13D Component Reliability Enhancement Techniques	
	10:15 - 12:15 PM	Session 14A Managing Risk in Aerospace Business Practices	Session 14B Designing Reliability into Large Scale Petrochemical Systems - Invited Sessiont	Tutorial 14C Fault Tree Analysis Using Binary Decision Diagrams	Session 14D Reliability-Driven Product Design	

Registration at the Pacific Registration Desk.
Monday 7:00 AM to 6:00 PM
Wednesday 7:00 AM to 3:30 PM
Sunday 3:30 to 6:00 PM
Tuesday 7:00 AM to 5:00 PM
Thursday 7:00 AM to 12:30 PM

Exhibits will be in the Newport Coast Ballroom.

MONDAY SCHEDULE

8:00 AM — 10:00 AM, Monday

Tutorial 1A — **INTRODUCTORY** — **Pacific Salon A/B**

RELIABILITY PROGRAM PLANNING FOR COMMERCIAL ENVIRONMENTS

James A. Hough, *Pitney Bowes*

This tutorial describes the development and implementation of a reliability program plan for commercial products that do not carry specific requirements or mandates from reliability programs. This tutorial focuses on the engineering analyses and activities that govern the inherent reliability of products.

8:00 AM — 12:15 AM, Monday

Tutorial 1B — **INTRODUCTORY** — **Pacific Salon C**

BASIC RELIABILITY

Dr. Kailash C. Kapur, *University of Washington*

This basic tutorial on reliability: design, engineering, testing and management covers an introduction and review of reliability methods that can be used throughout the LCC of the system. It will cover the following topics: Introduction to reliability and some global perspectives, reliability measures useful in industry, system reliability, reliability activities during the design and development phase, reliability estimation and the design and management of RAM process and its implementation.

Tutorial 1D — **INTRODUCTORY** — **Pacific Salon D**

PROBABILISTIC METHODS AND STATISTICAL METHODS IN RELIABILITY

Dr. David W. Coit, *Rutgers University*

This tutorial introduces probabilistic lifetime models and statistical methods for reliability modeling. Series systems, parallel systems, k-out-of-n systems, minimal path sets and minimal cut sets are some of the topics addressed. Statistical methods that can be applied to a complete or right-censored data set will be emphasized.

8:00 AM — 10:00 AM, Monday

Tutorial 1C — **INTERMEDIATE** — **Pacific Salon E/F**

MARKOV-CHAIN MODELING AND ANALYSIS

Dr. Lisa M. Maillart, *Case Western Reserve University* and **Dr. Edward A. Pohl,** *University of Arkansas*

Markov chains are a class of stochastic processes that can be used to model a wide variety of issues related to reliability and maintainability. This tutorial covers the fundamental concepts of discrete-time and continuous-time Markov chains and some advanced concepts related to Markov modeling and decision-making.

10:15 AM — 12:15 PM, Monday

Tutorial 2A — **SPECIAL TOPIC** — **Pacific Salon A/B**

SIX SIGMA PROCESS IMPROVEMENT OPPORTUNITIES

Dr. Samuel J. Keene, *Seagate Technology*

The Six Sigma process improves product reliability by focusing attention on defining, measuring, analyzing, improving and controlling the process. The analyses and supporting graphical tools used in each phase are discussed.

Tutorial 2C — **INTRODUCTORY** — **Pacific Salon E/F**

HUMAN RELIABILITY ANALYSIS

Joseph R. Fragola, PE, *SAIC*

This tutorial provides an awareness of the following aspects of human reliability: appropriate parameters, data sources, design tools, prediction methods, tests, verification tools and issues. The material is intended to acquaint the audience with the principal features of the concepts and tools, not to provide a computational proficiency.

1:15 PM — 2:00 PM, Monday

GENERAL CHAIR'S WELCOME AND KEYNOTE ADDRESS — **Pacific Salon C/D**

HIGHER RELIABILITY & IMPROVEMENTS IN MAINTAINABILITY LEAD TO LOWER LIFE CYCLE COSTS: FACT OR FICTION

Automakers have demonstrated that improving maintainability and reliability of automobiles is not only possible but can yield much lower operating and support costs of their vehicles within the warranty period. LTG Yakovac will explore the challenges and costs of improving reliability and maintainability of weapon systems and whether increased readiness and lower life cycle costs are worth the investment.

General Chair — Ron M. Adib, *RMA Consulting*

Keynote Speaker — Lieutenant General Joseph L. Yakovac, Jr., *Military Deputy to the Assistant cretary of the Army for Acquisition, Logistics and Technology (AL&T)*

LTG Yakovac, Jr.

Commissioned in the Infantry upon graduation from the United States Military Academy, Lieutenant General Yakovac has served in a variety of command and staff positions at company grade through general officer ranks. He was a Platoon Leader, Executive Officer and Company Commander in mechanized infantry units. Following these assignments, Lieutenant General Yakovac earned a Master of Science degree in Mechanical Engineering from the University of Colorado. He subsequently served as an Assistant Professor at the United States Military Academy.

Lieutenant General Yakovac's field grade assignments include Executive Officer and Branch Chief, Bradley Project Office; Brigade Logistics Officer, Brigade Operations Officer, and Battalion Executive Officer, US Army Europe; Staff Officer, Armor/Anti-Armor Task Force, Office of the Chief of Staff, Army; Mechanized Infantry Battalion Commander; Director, Weapons Systems Management Directorate, US Army Tank-automotive and Armaments Command; and Project Manager, Bradley Fighting Vehicle System.

Prior to Lieutenant General Yakovac's position as the MILDEP, which he assumed in November 03, he served most recently as the Program Executive Officer, Ground Combat and Support Systems, now known as Ground Combat Systems, and as Deputy for Systems Acquisition, US Army Tank-automotive and Armaments Command (TACOM). Before going to TACOM, his last position in the Pentagon was the Assistant Deputy for Systems Management and Horizontal Technology Integration, Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology).

Lieutenant General Yakovac is a graduate of the Armor Officer Advanced Course, the Army Command and General Staff College, the Defense Systems Management College and the Industrial College of the Armed Forces. He wears the Expert Infantry Badge, the Ranger Tab, the Parachutist Badge as well as the Distinguished Service Medal, three Legions of Merit and seven awards of the Army Meritorious Service Medal.

2:15 PM — 4:45 PM, Monday

Tutorial 4A **INTERMEDIATE** **Pacific Salon A/B**

RELIABILITY GROWTH TESTING AND DATA ANALYSIS

Dr. Larry H. Crow, *Crow Reliability Resources, Inc.*

This tutorial addresses models and procedures to assess reliability growth during development testing and in-service customer use. Methods useful in assessing and managing a reliability growth program are also discussed.

Tutorial 4B **INTRODUCTORY** **Pacific Salon C**

SOFTWARE RELIABILITY THROUGH DoE

Dr. Madhav S. Phadke, *Phadke Associates Inc.*

Software reliability has three distinct aspects: how build reliability into the product, how to test the product, and how to measure the failure rate. Robust Testing, the focus of this tutorial, focuses attention on the usage of the software, and uses orthogonal arrays to span the entire operating domain uniformly, and with a minimum number of test cases. It reduces the testing cost, product introduction delays, and sends fewer faults to the field.

Tutorial 4C **INTERMEDIATE** **Pacific Salon E/F**

INTRODUCTION TO REPAIRABLE SYSTEMS MODELING

Dr. C. Richard Cassady, *University of Arkansas*

This tutorial is an introduction to the basic concepts of modeling repairable systems. The common assumptions and modeling approaches employed in maintenance modeling and optimization are emphasized. Some level of mathematical sophistication is required, however, the mathematical theory and derivations are not the focus of this tutorial.

Workshop 4D **Pacific Salon D**

R&M EXHIBITORS PRESENTATIONS AND DEMONSTRATIONS

Moderator: Thomas L. Brogan, *Raytheon Company*

R&M CAE tools continue to evolve in support of industry's business processes. Our RAMS Exhibitors will highlight their latest functionality through brief presentations and application demonstrations in a neutral setting. Please check outside the room for the vendor presentation schedule.

TUESDAY SCHEDULE

8:00 AM — 1:30 PM, Tuesday

Workshop **Copper Cove**

REVIEW SESSION FOR ASQ CRE EXAM

This session is for the benefit of those attendees who are registered to take the ASQ CRE Examination or are considering taking this examination this week or some time in the future, or are simply curious. Experts in the reliability field will review examination material. For registration information, refer to page 4.

8:00 AM — 10:00 AM, Tuesday

Session 5A **Pacific Salon A/B**

PRODUCT VERIFICATION AND VALIDATION: WHEN IS GOOD. GOOD ENOUGH?

Moderator: Ken Schmidt, *Optim Associates*

An oveview of recent advances in reliability testing including case studies**.**

5A1 **A STUDY OF THE IMPACT OF PROGNOSTIC ERRORS ON SYSTEM PERFORMANCE**

Mauricio Carrasco and **Dr. C. Richard Cassady,** *University of Arkansas*

The challenge associated with prognostics is developing a system assessment mechanism that is both economically feasible and statistically valid as a means of predicting remaining system life. Our focus is on the second aspect of this challenge – statistical errors. Once a system assessment has been made, the data taken from the system must be converted using some algorithm into an estimate of the system's remaining life.

5A2 **VIRTUAL VALIDATION AND VERIFICATION OF A PRODUCT SPECIFICATION**

Muchiu Chang, *Ching Yun University*

Because a product design approach suffers from risks in schedule and cost during the traditional prototype building validation and verification (V&V) and lacks a over-all picture of the product at its concept design stage when no actual hardware and software are available in hand, we propose an integrated virtual method to validate and verify the performance and the cost effectiveness of a new product design simultaneously by using mathematical model.

5A3 PRODUCT RELIABILITY VALIDATION AND CONTINUOUS IMPROVEMENT AT GE ENERGY

Dr. Randolph Phillips, *General Electric Company*

The GE Energy portfolio of products has expanded over the last ten years from traditional heavy duty gas and steam turbines to include a broad spectrum of technologies including wind turbines, sensors, controls, energy management systems, reciprocating engines, compressors and more. To ensure future New Product Introduction programs meet their reliability targets requires designers have the benefit of all past lessons learned. This requires a disciplined approach to field data collection.

5A4 A BEHAVIOR-BASED PROCESS FOR EVALUATING AVAILABILITY ACHIEVEMENT RISK USING STOCHASTIC ACTIVITY NETWORKS

Tod Courtney and **Dr. William H. Sanders,** *University of Illinois at Urbana Champaign*

With increased focus on the availability performance of complex, multifunction systems, modeling processes and analytical tools are needed that help the Availability Systems Engineer to understand the impact of architectural and logistics support choices on system availability. This paper describes a two-part availability performance estimation methodology that starts with a description of the system's complex availability related behavior and then calculates an estimate of availability.

5A5 ACCESSIBLE FORMAL VERIFICATION FOR SAFETY-CRITICAL HARDWARE DESIGN

Dr. John Lach , *University of Virginia,* **Thuy Nguyen** and **Patrick Salaun,** *Electricite de France*

This paper presents work on the development of a technique to make formal verification more accessible to specification and design engineers by creating a library that abstracts the formal domain into a verified set of basic operations and components.

5A6 MANAGING RISK BY EXTRACTING MANAGEMENT INFORMATION AND DESIGN FEED BACK FROM FIELD FAILURE DATA

Valter Loll, *Nokia Mobile Phones R&D*

With short product development time and high reliability for modern products, precise estimates of the reliability of a product can often only be based on field data. Accumulated failure curves based on superimposed renewal process have been known for 20 years but are not widely used. This simple method gives valuable information for top management as well as design feedback.

Tutorial 5B **INTERMEDIATE** **Pacific Salon C**

PLANNING AND PERFORMING SOFTWARE FMEA

Nathaniel Ozarin, *The Omnicon Group, Inc.*

Failure Mode Effects Analyses have proven to be an effective method for improving the reliability of hardware systems but many still consider software FMEAs to be problematic. This tutorial provides a proven methodology and a detailed example for planning and performing software FMEAs.

Tutorial 5C **INTRODUCTORY** **Pacific Salon E/F**

STATISTICAL ANALYSIS OF FIELD DATA FOR REPAIRABLE SYSTEMS

Dr. David C. Trindade and **Dr. Swami Nathan,** *Sun Microsystems Inc.*

This tutorial presents modern techniques of statistical analysis of field data useful for characterizing reliability behavior of repairable systems. The limitations of using summary statistics, such as MTBF, are reviewed and modern methods that can include the analysis of time dependent reliability are presented. Data requirements and actual field data examples are included.

Session 5D **Pacific Salon D**

HUMANS IN THE LOOP: MANAGING RISK VIA ASSESSMENT AND MITIGATION OF HUMAN FACTORS

Moderator: Joseph R. Fragola, PE, *SAIC*

Humans are highly reliable as a system, but involve many failure modes that are challenge to mitigate. This session will provide insight into human reliability and how human input to a system can be optimized.

5D1 CUSTOMER FEEDBACK BEFORE MARKET RELEASE: A CASE STUDY

Dr. Valia T. Petkova, Dr. Peter C. Sander, and **Yuan Lu,** *Eindhoven University of Technology*

This paper concerns the verification and validation of products. In particular for innovative products it is nearly impossible to foresee all quality and reliability problems that may show up in the field. If the technical root cause of a field problem zcan be located, the manufacturer might be able to improve the product. Therefore field feedback is indispensable.

5D2 HUMAN RELIABILITY ISSUES IN MEDICAL CARE - A CUSTOMER VIEWPOINT

Aron Brall, *SRS Technologies*

Significant publicity has recently been given to deaths, incorrect treatments, etc. in America's hospitals due to human error. This paper is not a critique of diagnosis or treatment decisions, but of management and communication systems used in determining and implementing diagnoses and treatments.

5D3 COGNITIVE MODELING OF UNDERGROUND MINERS RESPONSE TO ACCIDENTS

Dr. Surendra Mohan and **Dayse Cavalcanti de Lemos Duarte,** *Federal University of Pernambuco*

The scope of this paper is to deal with human error to prepare a cycle and a matrix of various human and other existing factors and a cognitive model for miners working in underground mines under unnatural and hazardous environmental conditions having the constant fear of accidents.

5D4 RISK ASSESSMENT WHEN MALEVOLENT ACTIONS ARE INVOLVED

Dr. Terry F. Bott and **Stephen W. Eisenhawer,** *Los Alamos National Laboratory*

When malevolent intention is the primary cause of loss, the relative probability of the different scenarios is dependent on the adversary's knowledge, capabilities, and objectives and on the protective or mitigating measures in place to protect the target. Inclusion of these factors in the risk analysis requires some extension of the traditional techniques.

Tutorial Session 5E **INTERMEDIATE** **Avalon**

SIMULATION MODELING FOR RELIABILITY ANALYSIS

Dr. Edward F. Mykytka and **Dr. Joseph R. Litko,** *University of Dayton*

This tutorial introduces simulation as a reliability modeling method. Special emphasis is placed on the statistical aspects of analyzing simulation output. On completion of this tutorial, a reliability practitioner should know the fundamentals of simulation and be able to assess the merits of pursuing simulation as a modeling option.

10:15 AM — 12:15 PM, Tuesday

Session 6A **Pacific Salon A/B**

EMERGING TECHNOLOGIES AND TRENDS

Moderator: Joseph A. Dzekevich, *Raytheon Company*

This session presents the latest RMA techniques in areas of probabilistic risk assessment, Petri nets, vulnerability discovery and nanotechnology safety.

6A1 EMERGING PROBABILISTIC TECHNOLOGY AND ITS APPLICATION TO RELIABILITY PREDICTION AND RISK ASSESSMENT

Mohammad R. Khalessi, Hong-Zong Li , *PredictionProbe, Inc.,* **Robert Kuper** and **Anthony D'Angelo,** *U.S. Army ARDEC*

This paper describes the use of Probabilistic Design methodologies that considers both statistical and physical aspects of a process taking into account uncertainty and risk, thus providing more accurate results and efficiencies while also reducing costs.

6A2 CURRENT KNOWLEDGE ABOUT NANOTECHNOLOGY SAFETY

Koushik Datta, Christopher B. Wiltsee and **Anthony Briceno,** *NASA Ames*

Nanotechnologies are showing up in industrial, medical and military applications without any current safety regulations. This paper discusses the current knowledge about the safety of nanomaterials.

6A3 STOCHASTIC PETRI NETS MODELING USING SPN

Dr. Vitali Volovoi, *Georgia Institute of Technology*

This paper introduces SPN@, a tool for the graphical modeling of intricate dynamics scenarios relevant to safety, reliability, and availability. The SPN@ methodology is a novel concept of aging tokens, enhancing Colored Stochastic Petri Net formalism and providing a visual and practical means for assessing these scenarios.

6A4 QUANTITATIVE RISK ASSESSMENT FOR DEPENDENT VULNERABILITIES

Dr. Mehmet Sahinoglu, *Troy State University*

This paper introduces a Security Meter design analysis technique that offers a quick way of calculating a system's software risk to attack that is practical and simple to use for a beginner.

6A5 PREDICTION CAPABILITIES OF VULNERABILITY DISCOVERY MODELS

Omar H. Alhazmi and **Dr. Yashwant K. Malaiya,** *Colorado State University*

Security vulnerabilities on operating systems have emerged as major threats. This paper examines the prediction capability, limitations of and computational approaches of vulnerability discovery models.

Session 6B **Pacific Salon C**

SOFTWARE RELIABILITY AND TESTING

Moderator: Dr. Liudong Xing, *University of Massachusetts*

This session covers different elements of software reliability, including setting up requirement, planning test and applying statistical testing to software reliability.

6B1 RESOURCE ALLOCATION MODELS FOR SOFTWARE MODULE TESTING

Dr. Ravindra B. Misra and **Rani Rajan,** *Indian Institute of Technology*

This paper presents a mathematical formulation to obtain the failure rate of a modular software system by considering fault correction as well as fault detection activities. Further, this paper focuses on solving optimal testing resource allocation problems using the proposed failure rate model.

6B2 THE APPLICATION OF STATISTICAL TESTING TO SMART SENSOR SOFTWARE

Silke Kuball, Julio Cesar Gallardo, and **John May,** *University of Bristol*

This paper looks at the use of statistical testing techniques on smart devices that might find use in the nuclear industry.

6B3 OPTIMAL TESTING RESOURCE ALLOCATION MODELS FOR MODULAR SOFTWARE

Rani Rajan and **Dr. Ravindra B. Misra,** *Indian Institute of Technology*

This paper proposes a generic cost function, which incorporates failure cost as a quality measure.

6B4 BETTER SOFTWARE RELIABILITY BY GETTING THE REQUIREMENTS RIGHT

Dr. John B. Bowles, *University of South Carolina*

For too long software has been produced using processes that result in a product that is completed late, over-budget, and below the quality expectations of end users; getting the requirements right the first time, is the key to building reliable software products.

Tutorial 6C **INTRODUCTORY** **Pacific Salon E/F**

RELIABILITY FROM PRODUCT DESIGN INCEPTION TO PRODUCT RETIREMENT

Dr. Duane L. Dietrich, *ReliaSoft*

In this tutorial an outline of a cohesive structure for reliability testing throughout a product's life cycle is presented. In this structure the design of each successive test is based on analysis, expert opinion, past data obtained from similar products in the field, and data from earlier tests. The appropriate location and use of several different reliability tests are discussed and the implementation of engineering change orders to fielded units to reduce failures is covered.

Workshop 6D **Pacific Salon D**

R&M EXHIBITOR PRESENTATIONS & DEMONSTRATIONS

Moderator: Thomas L. Brogan, *Raytheon Company*

R&M CAE tools continue to evolve in support of industry's business practices. Our RAMS Exhibitors will highlight their latest functionality through brief presentations and application demonstrations in a neutral setting. Please check outside the room for the vendor presentation schedules.

Session 6E **Avalon**

NEW PRODUCT LIFE ANALYSIS TECHNIQUES TO OPTIMIZING OPERATIONAL RELIABILITY

Moderator: Richard J. Rudy, *VEXTEC Consultant*

Advances in reliability analysis including case studies.

6E1 LIFE MANAGEMENT OF POWER PLANT EQUIPMENT AT GE ENERGY

Dr. Randolph Phillips, *General Electric Company*

To better manage and cap the life cycle cost risk of operating a power plant using a heavy-duty gas turbine, owners and OEMs have found mutual benefit is long-term service agreements mostly centered on the high value gas turbine capital parts. To manage these agreements and realize optimal cost productivity over the life of the contract requires a commitment to a life management program that continually improves the OEMs ability to accurately predict residual life.

6E2 PROTOCOL: AN ON-LINE ENVIRONMENT FOR REDUCING PRODUCT RELIABILITY RISK

Preston MacDiarmid, David Mahar, *Quanterion Solutions Incorporated,* **Jessica Glover** and **Wyatt E. Shankle,** *Army Aviation and Missile RD&E Center*

Military program offices and commercial product developers are challenged to make effective reliability decisions throughout product/systems development, acquisition, production and operation/maintenance phases. The decisions range from determining what reliability goals/requirements are appropriate to meet user's mission needs and market demands to selecting the most cost effective means to assess whether the system reliability is adequate to pass through various program decision "gates."

6E3 PREDICTING REMAINING USEFUL LIFE OF AN INDIVIDUAL UNIT USING PROPORTIONAL HAZARDS MODEL AND LOGISTIC REGRESSION MODEL

Haitao Liao, *Wichita State University*

Reliability of an individual unit during field use is critical in field applications such as turbine engines, life-maintaining systems and civil engineering structures. The residual life of the unit indicates its ability of surviving the usage in the future. In recent years, the residual life prediction in service receives increasing attention. When initial failure indication has been detected, it is essential to estimate the residual life accurately.

6E4 FATIGUE ANALYSIS FRAMEWORK FOR FLEET MANAGEMENT USING BAYESIAN NETWORKS

Tony J. Rosqvist, Keijo Koski, *VTT Industrial Systems,* and **Aslak Siljander,** *VTT Industrial Systems, Aircraft Structures*

The aim of the paper is to introduce a fatigue analysis framework to support the management of a fleet of aircraft. The challenge faced by the fleet manager is to organize and manage the fleet such that operational and training objectives are met while at the same time constraints related to a safety of flight, fleet availability, maintenance actions and maintenance costs, and planned Out of Service Date are complied with.

6E5 RELIABILITY ANALYSIS OF MECHATRONIC SYSTEMS USING CENSORING DATA AND PETRI NETS: APPLICATION ON AN ANTILOCK BRAKE SYSTEM

Alin Mihalache, Mihaela Barreau, Alexis Todoskoff and **Prof. Fabrice Guerin,** *I.S.T.I.A - LASQUO*

Mechatronic systems have a potential impact on people's safety and technological progress increases not only their performance but also their importance. Therefore, the reliability analysis is a very important engineering issue, in order to guarantee their functional behavior. Since these systems are very complex to study, the evaluation of their reliability is extremely difficult.

1:30 AM — 3:30 PM, Tuesday

Session 7A **Pacific Salon A/B**

RELIABILITY, AVAILABILITY & PROGNOSTICS, RETURN ON INVESTMENT

Moderator: Dennis R. Hoffman, *Lockheed Martin Aeronautics*

Product reliability is a selling point, and thus a financial benefit. Companies that understand this are successful. Since financial terms are the language of management, reliability needs to express their performance parameters in financial terms to aid in management buy-in and acceptance. These papers will provide insight into what has worked and may work for you.

7A1 OPTIMAL RELIABILITY AND PRICE CHOICES FOR PRODUCTS UNDER WARRANTY

Zhi-Jie Liu, *Dalian University of Technology,* **Dr. Hong-Zhong Huang,** *Northwestern University,* and **Dr. D. N. P. Murthy,** *The University of Queensland*

An optimal reliability and warranty strategy model allows for achievement of the largest profit under a free replacement warranty strategy.

7A2 **AVAILABILITY GUARANTEES AND PHYSICAL ASSETS MANAGEMENT: EMPHIRICAL EVIDENCE OF THE IMPACT OF SOME UNDERLYING FACTORS**
Kari Komonen, *Technical Research Centre of Finland,* and **Dr. Helena Kortelainen,** *VTT Industrial Systems*
Availability performance of production industrial machinery is very critical which has raised the demand for higher reliability and for availability guarantees during equipment acquisition.

7A3 **PREDICTION OF WARRANTY RISK AND LIFE DISTRIBUTION BASED UPON EARLY WARRANTY DATA**
Dustin Aldridge, *Delphi Corporation, Energy & Chassis Division*
Philosophy and approach, supported by case studies, of warranty data analysis is utilized to predict risk and to drive earlier action.

7A4 **PROGNOSTICS FOR ELECTRONIC EQUIPMENT - AN ECONOMIC PERSPECTIVE**
Dr. Herbert Hecht, *SoHaR Inc.*
Prognostics have been successfully applied in various sectors but one area, electronic equipment, although extremely desirable, present numerous obstacles.

7A5 **APPLICATION OF PROACTIVE QUALITY METHODS TO INCREASE BUSINESS VALUE**
Suheil M. Nassar, *IBM Corporation*
Application of proactive methodologies during development provide opportunities to save significant costs while still improving product design, quality, and customer satisfaction.

Session 7B **Pacific Salon C**
PRACTICAL DATA ANALYSIS, EMERGING TOOLS AND TECHNIQUES
Moderator: Harold E. Ascher, *Harold E. Ascher & Associates*
This session provides a variety of new tools and techniques for analyzing repairable system data, multi-state systems as well as some new distributional forms useful to today's reliability analyst.

7B1 **SUMS, PRODUCTS AND RATIOS FOR SOME J-SHAPED DISTRIBUTIONS**
Meijian Zhou, Dong Won Yang, Yi Wang, and **Saralees Nadarajah,** *University of Nebraska*
This paper explores the use and applicability of the J-shaped distribution as a model of failure data.

7B2 **PRACTICAL METHODS FOR THE MODELING OF REPAIRABLE SYSTEMS WITH TIME TREND AND REPAIR EFFECT**
Huairui Guo, *ReliaSoft Corporation,* **Dr. Wenbiao Zhao,** *American Express,* and **Adamantios Mettas,** *ReliaSoft Corporation*
A practical model based on the Proportional Intensity (PI) model is presented for analyzing repairable systems. This model overcomes the drawbacks of traditional models and can be easily extended to reliability growth modeling. The authors demonstrate their approach using two different case studies.

7B3 **A NEW MODELING APPROACH — DYNAMIC RELIABILITY BLOCK DIAGRAMS**
Salvatore Distefano and **Dr. Liudong Xing,** *University of Massachusetts*
A new modeling tool is proposed that extends, and enhances the existing reliability block diagramming formalisms. The capabilities of this new tool are illustrated using a DRBD model of a computer system.

7B4 **THE APPLICATION OF THE BOX-TIDWELL TRANSFORMATION IN RELIABILITY MODELING**
Toby Joyce, *Bell Labs Research Ireland,* **Dr. John Donovan,** *Institute of Technology,* and **Dr. Eamonn Murphy,** *University of Limerick*
This paper takes an original approach to fitting data to the power law model by using regression techniques such as the Box-Tidwell transformation.

7B5 **PRIOR SPECIFICATION FOR MULTI-FAILURE MODE WEIBULL RELIABILITY MODELS**
Dr. Frank J. Groen, *Prediction Technologies, Inc.* and **Dr. Enrique Lopez Droguett,** *Federal University of Pernambuco*
This paper presents a procedure for the specification of informed prior distributions for a model in which the system reliability is modeled as a set of competing failure modes.

Tutorial 7C **INTRODUCTORY** **Pacific Salon E/F**
IMPROVING PRODUCTION THROUGH RELIABILITY USING AVAILABLE INFORMATION
Aron Brall, *SRS Technologies*
This tutorial describes a sequential set of methodologies that can be applied to manufacturing processes for the purpose of improving the reliability and availability of production equipment. Key parts of this tutorial include identifying types of data the at are readily available and issues related to implementing corrective actions.

Plan now to present a paper, tutorial or to attend the Year 2007 RAMS. For more information, visit our Web site at: http://www.rams.org.

Session 7D **Pacific Salon D**

MEET THE RELIABILITY FACULTIES - INVITED SESSION

Moderator: Dr. Duane L. Dietrich, *ReliaSoft*

There are a half a dozen or so reliability faculty that we all know and that have been around for a long time. This session is dedicated to show casing some of the newer reliability faculty in the major reliability academic programs within the US.

7D1 A COMPARISON OF ACCELERATED LIFE TESTING DESIGNS WITHIN A SINGLE BAYESIAN FRAMEWORK

Dr. J. Rene van Dorp, Dr. Thomas A. Mazzuchi and **Dr. Jorge E. Garciduenas,** *The George Washington University*

This paper extends the original research work done by Van Dorp and Mazzuchi where a step stress accelerated life testing metrology was used to test for the failures of components, subsystems, and systems. This extension amplifies the application of Bayesian modeling to compare various other stress patterns.

7D2 MODELING LOW PROBABILITY/HIGH CONSEQUENCE EVENTS: AN AVIATION SAFETY RISK MODEL

James T. Luxhoj and **Dr. David W. Coit,** *Rutgers University*

Failure events that occur with a very low probability, but with extreme consequences, presents an interesting modeling challenge because of the scarcity of representative empirical data. An Aviation System Risk Model, based on Bayesian belief networks, is introduced to assess the impact of new technology insertions or products designed to mitigate the likelihood or consequence of aviation accidents.

7D3 UNCERTAINTY ASSESSMENT FOR AVAILABILITY: IMPORTANCE MEASURE

Mehmet Miman and **Dr. Edward A. Pohl,** *University of Arkansas*

This paper develops and illustrates a system availability importance measure that considers the impact of a components variance. This variance importance measure will enable test engineers and designers to prioritize their improvement actions by allocating resources to various components in a system more effectively.

7D4 RESEARCH IN SOFTWARE RELIABILITY ENGINEERING

Dr. Carol Sophie Smidts, *University of Maryland*

The paper summarizes research advances in software reliability modeling, integration of software risk in probabilistic risk assessment for large technological systems and automation of software reliability-based testing and discusses open questions related to these research areas

Tutorial 7E **INTERMEDIATE** **Avalon**

EMPIRICAL METHODS FOR PROCESS AND EQUIPMENT CONDITION MONITORING

Dr. J. Wesley Hines, *The University of Tennessee*

This tutorial addresses the general principles of condition-based maintenance from data collection to model development to implementation. The discussion of the principles of condition-based maintenance is supplemented with presentation of industrial case studies.

3:45 AM — 5:45 PM, Tuesday

Session 8A **Pacific Salon A/B**

USING KEY PERFORMANCE PARAMETERS (KPP) TO IMPROVE RELIABILITY

Moderator: Anthony J. DiVenti, *NASA Goddard Spaceflight Center*

The use of metrics to quantify and evaluate Reliability & Maintainability characteristics has provided great insight into design, operational and other factors that impact systems throughout the life cycle. This session identifies Key Performance Parameters (KPP) (metrics) that have been established in applications and have resulted in the implementation of significant changes and improvements to processes, services and products.

8A1 RELIABILITY INDEX - A METHOD TO PREDICT FAILURE RATE AND MONITOR MATURITY OF MOBILE PHONES

Dr. U. Daya Perera, *Nokia UK Ltd*

A methodology for the assessment of product maturity and estimation of failure rates based on electronic, mechanical, environmental and electromagnetic factors is presented.

8A2 A STRUCTURED METHODOLOGY FOR IDENTIFYING PERFORMANCE METRICS AND MONITORING MAINTENANCE EFFECTIVENESS

Maria Mercedes Amoedo and **Dr. Mohammad Modarres,** *University of Maryland*

A new approach to maintenance management based on the Balanced Scorecard methodology.

8A3 USEFUL METRICS FOR MANAGING FAILURE MODE CORRECTIVE ACTION

Dr. Larry H. Crow, *Crow Reliability Resources, Inc.*

A discussion of the methods and metrics used to define, implement and assess a management strategy for corrective actions.

8A4 DYNAMIC RELIABILITY INDICES COMPUTATION FOR PARALLEL, SERIES AND K-OUT-OF-N MULTI-STATE SYSTEM BY STRUCTURE FUNCTION

Dr. Elena Zaitseva and **Vitaly Levashenko,** *University of Zilina*

A method of calculating performance measures for Multi-State Systems (MSS) is presented.

Session 8B **Pacific Salon C**

INNOVATIVE PLANNING TECHNIQUES FOR RELIABILITY AND MAINTAINABILITY

Moderator: Dr. David W. Coit, *Rutgers University*

A “pot-pourri” of tools and techniques are presented that are designed to assist R&M engineers in planning and analyzing their R&M efforts.

8B1 **BAYESIAN MODEL FOR EARLY RELIABILITY PREDICTION**

Dr. Roxana A. Ion, J. (Hans) Kalishoek, Dimitrios M. Karydas, and **Iulian Nitescu,** *Eindhoven University of Technology*

This paper provides a Bayesian model for estimating the failure probability in the field, early after a product has been introduced to the market. The model is demonstrated using field data and is shown to provide a more accurate prediction with less uncertainty as updated information becomes available.

8B2 **AN APPROACH TO RELIABILITY GROWTH PLANNING BASED ON FAILURE MODE DISCOVERY AND CORRECTION USING AMSAAS PROJECTION MODEL**

Dr. Paul M. Ellner and **J. Brian Hall,** *U.S. AMSAA*

Exact expressions for the expected number of surfaced failure modes and system failure intensity as functions of test time are presented under the assumption that the surfaced modes are mitigated through corrective actions.

8B3 **TOTAL LEAST SQUARES ANALYSIS FOR RELIABILITY MODELING OF WEIBULL DISTRIBUTION**

Rex Wang, Helios Chen and **L. W. Chen,** *National Cheng Kung University*

A new total least squares analysis method that allows measuration errors and uncertainties in lifetime observations is developed. To avoid the time consuming singular value decomposition algorithm regularly employed by the TLS analysis, closed-form solutions of the planar (2D) cases are derived using the Lagrange multiplier.

8B4 **USING MARKOV MODELS TO COMPUTE PFDAVE WHEN REPAIR TIMES ARE NOT EXPONENTIALLY DISTRIBUTED**

Dr. Julia V. Bukowski, *Villanova University*

Markov models for assessing safety system performance usually assume repair times are exponentially distributed, but generally they are not. This paper compares results for exponential and non-exponential repair times and indicates when the exponential assumption can be validly used.

8B5 **A NEW METHOD OF SYSTEM RELIABILITY OPTIMIZATION USING GENETIC ALGORITHM**

Dr. Hong-Zhong Huang, *Northwestern University,* **Jian Qu,** *Dalian University of Technology,* **Dr. Ming J. Zuo,** *University of Alberta,* and **Wei Chen,** *Northwestern University*

A multi-objective optimization algorithm for solving a mixed-integer programming problem that normally arises in system-reliability design is proposed. The algorithm uses a genetic algorithm based on Pareto tournament and equivalence sharing, and a population-based constraint handling method.

Tutorial 8C **INTERMEDIATE** **Pacific Salon E/F**

UNDERSTANDING ACCELERATED LIFE TESTING ANALYSIS

Pantelis Vassiliou and **Adamantios Mettas,** *ReliaSoft Corporation*

Correct analysis of data gathered from testing products under high-stress conditions provides important information for predicting and improving their life under use-stress conditions. This tutorial provides an introduction to the area of accelerated life testing. A number of practical examples are provided.

Panel 8D **Pacific Salon D**

PREVENTIVE AND PREDICTIVE MAINTENANCE - NECESSARY EVIL OR VALUABLE PRACTICE

Moderator: Richard J. Rudy,*VEXTEC Consultant*

A lively discussion among experts of the necessity and value of performing Preventive and Predictive Maintenance in the Manufacturing environment.

Panelists:

William F. Hagen, *Ford Motor Company*
Dr. Leonard Lamberson, *Western Michigan University*
Daniel M. Deans, *SRS Technologies*
Micheal Morse, *American Institute of Quality*

Session 8E **Avalon**

OPERATIONAL RELIABILITY REQUIREMENTS AND OPTIMIZATION

Moderator: Todd Heydt, *GE Healthcare*

Recently developed methods and simulation techniques, from system reliability prediction to allocation, are applied to Internet Service Provider networks, distributed electric power systems, and other professional fields.

8E1 **ENHANCING ISP NETWORK RELIABILITY BY INTEGRATED FRAMEWORK OFMULTI-OBJECTIVE GENETIC ALGORITHM AND MONTE CARLO SIMULATION**

Dohoon Kim, *Kyung Hee University*

It deals with an application of genetic algorithm to a multi-criteria decision context where not only cost-effective but also reliable Internet network should be configured.

8E2 **NEW ALLOCATION METHODS FOR REPAIRABLE SYSTEMS**

Dr. Suprasad V. Amari and **Vaishali Hegde,** Relex Software Corporation

This paper offers reliability engineers practical methods to achieve availability goals of repairable systems using allocations.

8E3 **FAULT TOLERANCE ADAPTATION REQUIREMENTS VS. QUALITY-OF-SERVICE, REALTIME AND SECURITY IN DYNAMIC DISTRIBUTED SYSTEMS**

Rodica Tirtea, Dr. Geert Deconinck, and **Ronnie J. M. Belmans,** *K. U. Leuven*

The relations between the requirements for adaptive fault tolerance support and real-time, quality-of-service and/or security are analyzed.

8E4 **SPECIFICATION AND ALLOCATION OF RELIABILITY AND AVAILABILITY REQUIREMENTS**
Dr. Seppo Virtanen and **Dr. Per-Erik Hagmark,** *Tampere University of Technology*
The paper presents a computer-supported method for specifying reliability, availability and repair time requirements for a product and allocating them into the product's design entities.

WEDNESDAY SCHEDULE

8:00 AM — 10:00 AM, Wednesday

Session 9A **Pacific Salon A/B**

ACCELERATED LIFE TESTING & AGING

Moderator: Adamantios Mettas, *ReliaSoft Corporation*

The emphasis of this session is on alternative approaches to accelerated life testing. Emphasis is placed on Bayesian methods, HALT testing, and unique applications of ALT.

9A1 **HALT VS. ALT: WHEN TO USE WHICH TECHNIQUE?**
Mike Silverman, *Ops A La Carte*
HALT and ALT are two most of the most effective reliability testing methods but often times people are confused about which to use when. In this paper, we shall examine when to use which technique, and when to use the two techniques together.

9A2 **ACCELERATED LIFE TESTS AT HIGHER USAGE RATES: A CASE STUDY**
Dr. Guangbin Yang and **Ziad Zaghati,** *Ford Motor Company*
The paper describes an acceleration model and optimum test plan for the accelerated life tests at higher usage rates. A case study is conducted to demonstrate the reliability of a type of compact relays.

9A3 **ACCELERATED LIFE TESTING FOR SPEEDER PRODUCT DEVELOPMENT: PROBLEMS AND STRATEGIES**
Sarath Jayatilleka, *Maytag Appliances,* and **Dr. O. Geoffrey Okogbaa,** *University of South Florida*
This paper addresses some practical hurdles that blocks the speedier new product development process and provides the strategies to over come them using accelerated life testing. The case is supported by examples from the appliance industry.

9A4 **BAYESIAN ESTIMATION IN ACCELERATED LIFE TESTING : APPLICATION ON EXPONENTIAL-ARRHENIUS MODEL**
Prof. Fabrice Guerin, *I.S.T.I.A – LASQUO,* **Sorin Voiculescu,** and **Prof. Bernard Dumon,** *I.S.T.I.A - Quality and Reliability Dept.*
In this paper, the Bayesian inference in accelerated life testing is studied for the Exponential - Arrhenius model and the obtained estimators are compared to those obtained by Maximum Likelihood for the same input. The study took into account expert opinions in order to cover the real world cases and showed the interest in using the Bayesian approach in integrating the available prior knowledge into model parameters.

Session 9B **Pacific Salon C**

INNOVATIVE APPROACHES IN MAINTAINABILITY AND RELIABILITY

Moderator: William F. Hagen, *Ford Motor Company*

Relating performance to Reliability, using Maintainability to mitigate risk, Optimizing Maintenance, applying Taguchi to reliability improvement - R&M engineers report on their innovation.

9B1 **USE OF R&M MEASURES IN AUSTRALIAN DEFENSE AEROSPACE PERFORMANCE BASED CONTRACTS**
Debbie Richardson and **Andrew Jacopino,** *Defence Materiel Organisation*
This paper identifies a four-step process for the development and implementation of a Performance Based contract from R&M theory, in the Australian Defense Aerospace environment.

9B2 **METHODOLOGY FOR MAINTAINABILITY-BASED RISK ASSESSMENT**
Walid M. Abdelmoez, Dr. Katerina Goseva, *Popstojanova,* and **Dr. Hany H. Ammar,** *West Virginia University*
Presents a methodology for assessing maintainability-based risk to account for changes in software system requirements. Maintainability-based risk is defined as a product of two factors: the probability of performing software maintenance tasks and the impact of performing these tasks.

9B3 **INTEGRATING DESIGN FOR PERFORMANCE AND RELIABILITY**
Yunxia Chen and **Rui Kang,** *Beihang University*
Presents an approach to integrate Reliability Design and Analysis with Performance Design and Analysis in complex systems.

Tutorial 9C **INTRODUCTORY** **Pacific Salon E/F**

WEIBULL ANALYSIS: METHODOLOGY, APPLICATIONS, BENEFITS AND PITFALLS

Les Warrington, *University of Warwick*

This tutorial provides an in-depth explanation of Weibull Analysis methodology. It covers the underlying theory, procedural applications, interpretation of results and the use of confidence limits. Limitations of the methodology, common mistakes and their avoidance are highlighted. Clear examples supported by both manual analysis methods and modern software are employed.

Panel 9D **Pacific Salon D**

LOGISTICS - TRANSITION OF ACQUISITION AND SUSTAINMENT OF PRODUCTS AND SERVICES FOR THE DEPARTMENT OF DEFENSE (DOD)

Moderator: Dr. Ralph L. Harper Jr., *HarCon, Inc.*

The Logistics Panel will cover Transition of Acquisition and Sustainment of products and services for the Department of Defense (DOD). As the United States DOD undergoes a major war fighting transformation from the legacy to the objective force, it faces and needs to address significant logistics sustainment challenges to ensure that its objective force will have the robust infrastructure necessary to fight and win across the full spectrum of future conflicts

Panelists:
Louis A Kratz, *US DoD, AT&L*
Thomas J. Edwards, *U.S. Army Combined Arms Support Command*
Col. Warren M. Anderson, *OUSD (AT&L)*
LTG(Ret) Roy E. Beauchamp, *Washington Group International*
Charles M. (Chuck) Huber, *Huber Consultants International*
Bob Kidwell, *ManTech International*
David J. Docguino, *Raytheon Technical Service Company*
Dr. Ralph L. Harper Jr., *HarCon, Inc.*
Haxel Estavillo, *Raytheon Integrated Defense Systems*

Session 9E **Avalon**

21ST CENTURY RELIABILITY APPROACHES AND TOOLKITS

Moderator: Patrick M. Dallosta, *NTVI Federal, Inc.*

New reliability approaches and toolkits extend the range and scope of Reliability Analysis from the traditional functional areas of design, prediction and assessment to the Business Objective forum, where cost, "time-to-market" and customer satisfaction are stringent criteria for success.

9E1 A CASE FOR NEW STATISTICAL SOFTWARE TESTING MODELS
John May, Silke Kuball, and **Julio Cesar Gallardo,** *University of Bristol*
A discussion of the Statistical Software Testing (SST) methodology to dynamically test and assess a system's probability of failure.

9E2 A NEW APPROACH TO EVALUATE THE WORTHINESS OF REPAIR
Dipl.-Ing. Patrick Jager, Dipl.-Ing. Monika Trost, and **Dr-Ing. Bernd Bertsche,** *University of Stuttgart*
A method of evaluating the return on investment of a maintenance action at a certain point in time depending on the system condition and future income is presented.

9E3 CREATING A SENSIBLE DERATING SYSTEM
James A. McLinn, *Teradyne*
Derating is the intentional reduction of applied stress on a component in order to assure reliability. A series of derating guides have been issued by the military services as well as other groups. This paper explores and discusses issues associated with p roper component derating.

9E4 RELIABILITY PREDICTION FOR COMPLEX MEDICAL SYSTEMS
Dr. Roxana A. Ion, Dr.Ir. A.C. Brombacher, *Eindhoven University of Technology,* and **Dr. Martin Newby,** *City University*
A discussion of the use and analysis of field data to predict the occurrence of failures during the development process and the initial fielding period, and the implementation of feedback to facilitate problem resolution.

9E5 DESIGN OF A RELIABILITY CONCEPTION WITH IMPLEMENTATION OF COSTS BY A SEMANTIC NETWORK
Dipl.-Ing. Bettina Rzepka and **Dr-Ing. Bernd Bertsche,** *University of Stuttgart*
The cost balance between increasingly higher reliability requirements and shortened development time is addressed through the use of advanced mathematical modeling techniques.

10:15 AM — 12:15 PM, Wednesday

Panel 10A **Pacific Salon C/D**

SYMPOSIUM PANEL — RELIABILITY AND MAINTAINABILITY IN THE NEW FRONTIER

Moderator: Vernon W. (Bill) Wessel, *NASA Glenn Research Center*

Leaders from industry, academia and government will discuss reliability and maintainability for the new frontier in industry, defense and space exploration. Audience participation will be encouraged during the session and questions will be welcomed.

Panelists — Comprised of members of the RAMS Advisory Board
Frank Culbertson, *NASA*
Art Fornari, *Xerox*
Dr. Kailash C. Kapur, *University of Washington*
Dr. Way Kuo, *The University of Tennessee*
Bryan O'Connor, *NASA*
Dr. Ernest A. Seglie, *Office of the Secretary of Defense, DOT&E*
Mark Shaeffer, *US DoD (OSD-ATL)*
William L. Vantine, *The ARES Corporation*

1:30 PM — 3:30 PM, Wednesday

Session 11A **Pacific Salon A/B**

ACCELERATED LIFE AND ACCELERATED RELIABILITY GROWTH TESTING

Moderator: Hugh Wilson Broome, *East Tennessee State University*

This session has a mix of theory and applications. From a theoretical standpoint, both Relia Growth and Mixed Trunsored methods are covered. Applications of ALT to cooling fans and aged components are also covered.

11A1 COOLING FAN RELIABILITY: FAILURE CRITERIA, ACCELERATED LIFE TESTING, MODELING AND QUALIFICATION

Dr. Xijin Tian, *Hewlett-Packard Co.*

Based on field return and test data, the major failure mechanisms and failure modes of cooling fan systems are presented in this paper and the failure criteria and the reliability metrics are discussed. By critically comparing the accelerated life testing methods from various vendors, a practical accelerated life testing methodology is presented and a comprehensive reliability qualification procedure is proposed.

11A2 ACCELERATED RELIABILITY GROWTH TESTING AND DATA ANALYSIS METHOD

Milena Krasich, PE, *Bose Corporation*

Accelerated reliability growth tests are designed to demonstrate product reliability. Whether the individual stresses are applied simultaneously or in sequence, the times to failure in each stress are projected vs. product life, and then used as data in standard reliability growth statistical methods. This eliminates dependency of the test results on the test sequence producing a realistic product reliability estimate.

11A3 MIXED TRUNSORED MODEL WITH APPLICATION TO THE LIFETIME ESTIMATION OF MALCONDITION ITEMS

Dr. Hideo Hirose, *Kyushu Institute of Technology*

Assuming that a system consisting of fragile and durable items will fail if one of the items fails and that the system also consisting of malcondition items or good items will not fail, we estimate the probability distribution for the malcondition items using the mixed t runsored model which combines the parameters in the distribution for the failure data and those for the malconditioned data. The estimated parameters in the Weibull model are robust even if the censoring time varies.

11A4 RELIABILITY ANALYSIS OF AGED COMPONENTS

Jorge Marcos-Acevedo, *University of Vigo,* **Santiago Fernandez-Gomez,** *C2 Microsystems, Inc.,* **Juan Barbero,** *ALCATEL Spain,* and **Dr. Ramiro Alvarez-Santos,** *Universidad Politecnica de Madrid*

A large sample of TTL and CMOS components in operation 24/7 in an industrial environment for over 30 years was analyzed. This paper describes the analysis procedure, results obtained, and conclusions drawn.

Panel 11B **Pacific Salon C**

PROGNOSTICS HEALTH MANAGEMENT (PHM)

Moderator: Jim Lauffer, *DSI International*

The Panel will address the burning platform for Prognostic Health Management requirements and how these requirements must be integrated for a total Systems Engineering solution to achieve effective mission operation and support.

Panelists:
John B. Schoeder, *Air Force Research Laboratory*
Dr. Karl M. Reichard, *Penn State University*
Dr. Michael J. Roemer, *Impact Technologies*
Dr. Bruno Jambor, *Lockheed Martin Space System Company*

Tutorial 11C **INTERMEDIATE** **Pacific Salon E/F**

OPTIMIZING MAINTENANCE AND REPLACEMENT DECISIONS

Professor Andrew K. S. Jardine, *University of Toronto*

This tutorial describes a variety of topics designed to help engineers make more effective decisions regarding systems maintenance and replacement. Case studies related to component replacement, spares parts provisioning, and equipment inspection are included.

Session 11D **Pacific Salon D**

ADVANCES IN RISK ASSESSMENT

Moderator: Dr. Frank (Feng-Bin) Sun, *Western Digital*

This session presents some advanced risk assessment methods and approaches for “real world” scenarios.

11D1 INCORPORATING EXPERT KNOWLEDGE WHEN ESTIMATING PARAMETERS OF THE PROPORTIONAL HAZARDS MODEL

Ali Zuashkiani, Dr. Dragan Banjevic, and **Professor Andrew K. S. Jardine,** *University of Toronto*

Using expert’s knowledge in building Condition Based Maintenance (CBM) models.

11D2 RISK ASSESSMENT OF REAL TIME DIGITAL CONTROL SYSTEMS

Myron Hecht, *Aerospace Corp*

This paper describes methods for feasibly assessing risk in integrated hardware and software real-time control systems based on empirical measurements and use of stochastic models.

11D3 PRACTICAL EVALUATION OF THE REMM PROCESS
Dr. Jane Marshall, *University of Warwick,* **Mick Balderstone,** *Smiths Aerospace,* **David Lumbard,** *Westland Helicopters Ltd,* and **Graham Tanner,** *Rolls Royce*
This paper summarizes the practical application of REMM using a number of real industrial case studies.

11D4 THE RELIABILITY OF CORRELATED TWO UNIT SYSTEMS
Huseyin Sarper and **Dr. Paul Chacon,** *Colorado State University*
Two-unit systems, for minimum life (serial) and for maximum life (parallel), with correlated lives are studied using bivariate exponential and bivariate normal distributions.

Session 11E **Avalon**
INNOVATIONS IN HIERARCHICAL ANALYSIS AND MODELING
Moderator: Mary Rowzee, *Daimler Chrysler Corporation*
An overview of recent advances in contemporary fault tree analysis and hierarchical modeling

11E1 A HYBRID FUZZY-MONTE CARLO SIMULATION APPROACH FOR FAULT TREE ANALYSIS
Saman Aliari Zonouz and **Dr. Seyyed Ghassem Miremadi,** *Sharif University of Technology*
Fault tree analysis is one of the key approaches which are applied for the reliability analysis of critical systems. Fault trees are usually analyzed using analytic approaches or Monte Carlo simulation (MCS). This paper presents a new hybrid Fuzzy-Monte Carlo (FMC) simulation approach in which the uncertain data is generated by this MCS approach.

11E2 A TOOL FOR AUTOMATICALLY TRANSLATING DYNAMIC FAULT TREES INTO DYNAMIC BAYESIAN NETWORKS
Dr. Stefania Montani, Prof. Luigi Portinale, and **Andrea Bobbio,** *Universita' del Piemonte Orientale*
The modeling possibilities offered by Fault Trees (FT), one of the most popular techniques for dependability analysis of large, safety critical systems, can be extended by relying on Bayesian Networks. This formalism allows to relax some constraints which are typical of FT, such as the hypothesis that elementary events are always modeled as binary objects (working/failed), are probabilistically independent, and interact just through Boolean AND/OR connections.

11E3 BDD BASED ANALYSIS OF PARAMETRIC FAULT TREES
Daniele Codetta-Raiteri, *Universita del Piemonte Orientale*
The Fault Tree is a widespread model in reliability analysis. Since its introduction, Fault Tree model has gained widespread acceptance due to intuitive notion and easy manipulation.

11E4 TERRIORIST RISK AND PROTECTION EVALUATION USING A POSTERIORI FAULT TREES
Dr. Martin L. Shooman, *Polytechnic University*
Risk analysis is a powerful tool that can be used to quantify decisions that are made in protecting or responding to a terrorist act. There are several probabilistic methodologies that can be used to evaluate such the probability of occurrence and risk of such events. In general these analyses are driven by the probability of occurrence of the various events, and the accuracy and utility of the analysis is directly related to the accuracy of the occurrence data.

11E5 A BDD & SEA BASED ANALYSIS OF GENERALIZED PHASED-MISSION RELIABILITY
Dr. Guangyu Chen, Xizi Huang, and **Xiaowo Tang,** *Univ. of Elec. Science and Tech. of China*
Accounting for the reliability analysis of a generalized phased-mission system (GPMS) with two-level modular imperfect coverage (MIPC), the dynamic behavior & the statistical dependencies across phases are the most important factors for reliability modeling & analysis. There exist several approaches, such as a family of decision diagrams called ternary decision diagrams (TDD) and a multi-state binary decision diagram (MBDD) based approach, proposed for the GPMS reliability evaluation.

3:45 PM — 5:45 PM, Wednesday

Panel 12A **Pacific Salon A/B**
ACHIEVING R & M FOR THE ARMY'S FUTURE COMBAT SYSTEM
Moderators: Melvin R. Downes, Jr., *US Army, Program Manager for Unit of Action,* and **Brian Knapczyk,** *Boeing Integrated Defense Systems*
A panel of Army, Boeing and key FCS suppliers will present their current and state-of-the-art methods for achieving R&M requirements and share their success stories as well as lessons learned. Boeing and the Army will provide a presentation of the program, schedule and brief description of the R&M strategy, requirements, modeling and metrics including some recently approved incentives and improvement programs. The FCS suppliers will focus on specific subsystem/component R&M challenges in Product Design; the design tools and best practices used; Accelerated Life Testing & Aging; and resulting changes in designs to date.

Panelists:
Phil Hodges, *PM for Future Combat System-Supportability*
Reg Varga, *Boeing Integrated Defense Systems*
Hugo Croft, *BAE Systems*
Steve Franz, *General Dynamics Land Systems*
Michael Roberts, *Northrup Grumman*
Jay Mork, *General Dynamics Advanced Information Systems*
Dennis Youngworth, *BAE Systems*

Session 12B **Pacific Salon C**

MAINTAINABILITY, MAINTENANCE AND PLANNING - APPROACHES TO REAL WORLD AVAILABILITY IMPROVEMENT

Moderator: Edward J. Zampino, *NASA Glenn Research Center*

Practical applications of Maintainability and Maintenance to assure system Availability in Manufacturing, Defense, and Nuclear Power generation, plus some theory on condition monitoring.

12B1 COST EFFECTIVE CONDITION-BASED MAINTENANCE USING MARKOV DECISION PROCESSES

Dr. Suprasad V. Amari, Leland McLaughlin, *Relex Software Corporation,* and **Dr. Hoang Pham,** *Rutgers University*

A generalized Condition Based Maintenance model is presented that can be applied to a wide range of applications. The model includes a stochastic deterioration process, a set of maintenance actions and their effects, and a scheduled inspection policy that identifies the condition of deterioration.

12B2 MODELLING IMPERFECT INSPECTION AND MAINTENANCE IN DEFENSE AVIATION THROUGH BAYESIAN ANALYSIS

Andrew Jacopino, *Defence Materiel Organisation,* **Dr. Frank J. Groen,** *Prediction Technologies, Inc.,* and **Dr. Ali Mosleh,** *University of Maryland*

Describes a model, the General Renewal Process introduced by KIJIMA and SUMITA, that more realistically represents the true life of a Repairable Item within the defense aviation environment. The model can adapt to the limitations in data and include a number of additional factors including aging of the component, number of repairs, effectiveness of the repair, skill of the technicians, etc.

12B3 OPTIMIZATION OF THE MONITORING DEVICE PERFORMANCE FOR A PREVENTIVE MAINTENANCE POLICY

Anne Barros, Dr. C. Berenguer, and **Dr. A. Grall,** *Universite de Technologie de Troyes*

A very simple optimization scheme is presented, in which the optimal monitoring technology or structure can be chosen among a finite set of possible ones, on the basis of their impact on the maintenance performance and their own cost. At the same time, the maintenance parameters are optimally tuned to adapt to the current monitoring quality level.

12B4 EFFECT OF A RELIABILITY & MAINTAINABILITY PROGRAM ON MANUFACTURING EQUIPMENT PERFORMANCE

William F. Hagen, *Ford Motor Company*

The basic reason to consider Reliability and Maintainability in manufacturing systems is to ensure maximization of production throughput. A well-defined R&M program can be shown to contribute to this goal by increasing the availability of the machines.

Tutorial 12C **INTERMEDIATE** **Pacific Salon E/F**

LESSONS LEARNED FOR EFFECTIVE FMEAS

Carl S. Carlson, *ReliaSoft Corporation*

FMEA has the potential to be a powerful reliability tool to reduce product design and manufacturing risk, yet often falls far short of this objective. This tutorial examines and discusses lessons learned from industry. Attendees will learn how to achieve effective results in their individual FMEAs and how to implement an effective FMEA process.

Session 12D **Pacific Salon D**

RISK ASSESSMENT: APPLICATIONS

Moderator: Dr. Thomas F. Hassett, *Consultant*

This session presents papers that focus on the practical applications of reliability risk assessment. Advanced modeling techniques employing new computer technologies and software are used to aid the research endeavors and provide meaningful examples.

12D1 RISK ASSESSMENT OF DERAILMENT INDUCED BY RAIL FAILURES - A PROBABILISTIC APPROACH

Jianmin Zhao, Andrew H. C. Chan and **Alan B. Stirling,** *The University of Birmingham*

This paper presents an approach to predict the occurrence of failures and the risk of accidents by the application of the stochastic and probability methods. The proposed model provides a tool to analyze the effects of rail reliability and different maintenance activities on the risk of derailment, and then a decision can be made to reduce the risk through rail maintenance and renewal policy.

12D2 RELATING RISK AND RELIABILITY PREDICTIONS TO DESIGN AND DEVELOPMENT CHOICES

Martin S. Feather and **Dr. Steven L. Cornford,** Jet Propulsion Laboratory

Risk and reliability predictions are done for a purpose - to yield information on which to base decisions (e.g., selection from among design alternatives). The explicit treatment of alternatives within a (simple) risk model, and its ramifications, are described and illustrated.

12D3 RELIABILITY ASSESSMENT OF OFFSHORE OIL MULTILATERAL WELLS IN BRAZIL

Dr. Enrique Lopez Droguett, Wagner Barbosa dos Santos, *Federal University of Pernambuco,* **Carlos Magno C. Jacinto** and **Gabriel Sotomayor,** *Petrobras*

This paper discusses the reliability assessment of multilateral wells construction process by means of a hybrid procedure based on event sequence diagrams with pivotal events characterized by Bayesian belief networks.

12D4 MODELING AND ANALYSIS OF CAUSES AND CONSEQUENCES OF FAILURES

Dr. Seppo Virtanen, Dr. Per-Erik Hagmark and **Jussi-Pekka Penttinen,** *Tampere University of Technology*

The paper presents a computer-supported method for modeling and analyzing causes and consequences of failures. In the developed method, the “cause tree” model is used to define causes and interconnected causalities that can lead to the occurrence of selected TOP-event, and “consequence tree” model again describes the possible chains of consequences initiated from the TOP-event.

12D5 **ELICITING ENGINEERING JUDGMENTS IN HUMAN RELIABILITY ASSESSMENT**
Paulo Renato Alves Firmino, Regilda da Costa Silva Menezes, and **Dayse Cavalcanti de Lemos Duarte,** *Federal University of Pernambuco*
This paper covers one of the main problems in the area of human reliability analysis (HRA), how to treat the scarcity of data. This issue also arises in the application of Bayesian belief networks (BBNs) to the context of HRA, which allow for the use of multidisciplinary knowledge in order to achieve more realistic models. Starting from two real problems a protocol is proposed for engineering elicitation of conditional probabilities.

Session 12E **Avalon**
INNOVATIONS IN FAILURE AND FAULT ANALYSIS
Moderator: Louis J. Gullo, *Raytheon*
This session presents the latest development in modeling and analyzing failure mechanisms, failure modes and failure effects.

12E1 **MICROSTRUCTURAL PHYSICS OF FAILURE MODELS TO PREDICT FATIGUE RELIABILITY**
Dr. Robert G. Tryon, Ganapathi Krishnan, and **Yaowu Zhao,** *VEXTEC Corporation*
The paper presents a method for predicting fatigue failure probability at the fleet level using a virtual testing software tool that simulates real material behavior at the microstructural level.

12E2 **REDUNDANCY OPTIMIZATION UNDER COMMON CAUSE FAILURE**
G.L. Pahuja, *National Institute of Technology* and **Dr. Krishna Gopal,** *Regional Engineering College*
Redundancy optimization for non-repairable systems under CCF has been attempted for the first time in this paper.

12E3 **FAILURE ANALYSIS OF A FAULT TOLERANT 2-NODE SERVER SYSTEM**
Daniel Jacob, Eric J. Simon, *Relex Software Corporation,* **Wei Zhang,** and **Dan Rose,** *StorageTek*
This paper presents an integrated model of hardware and software failures of a fault-tolerant 2-node server system used in a real-life application of an archive system.

12E4 **THE RISKS OF APPLYING QUALITATIVE PREDICTION METHODS: A CASE STUDY**
Ilse M. de Visser, *Eindhoven University of Technology* and **Johannes A. van den Bogaard,** *Technology Management Faculty of Eindhoven*
This paper illustrates the risks of applying qualitative reliability prediction methods in practice and makes suggestions for improving the application of these methods.

6:30 PM — 7:30 PM, Wednesday

GENERAL RECEPTION **Attrium**

7:30 PM — 10:00 PM, Wednesday

BANQUET **Grand Pacific Ballroom**

THURSDAY SCHEDULE

8:00 AM — 12:00 PM, Thursday

Worskshop 13E **Copper Cove**
ASQ CERTIFIED RELIABILITY ENGINEERING (CRE) AND SIX SIGMA BLACK BELT EXAMS
The exam will last 4 hours and consists of 150 questions. Registration closes at Noon on Wednesday for the CRE Exam. The 8 areas of the Body of Knowledge are covered in detail, be sure to study all and attend the review session on Tuesday. Calculators are suggested; non-programmable are the only ones permitted. Order a CRE Refresher Booklet from ASQ at 1-800-248-1946. Refer to page 4 for registration information.

8:00 AM — 10:00 AM, Thursday

Session 13A **Pacific Salon A/B**
DESIGNING SAFETY AND RELIABILITY INTO SPACE SYSTEMS
Moderator: Anthony J. DiVenti, *NASA Goddard Spaceflight Center*
Ensuring that safety and reliability are designed into space systems can be a challenge - see the current state-of-the-art techniques and results associated with design for safety and reliability techniques.

13A1 **DOES SOFIA REQUIRE A CREW ESCAPE SYSTEM?**
Koushik Datta, Christopher B. Wiltsee, and **Anthony Briceno,** *NASA Ames*
This paper depicts the rationale, based on reliability engineering, for making the decision for not requiring a crew escape system during the development-phase flight tests for a NASA system.

13A2 **RELIABILITY AND CREW SAFETY ASSESSMENT FOR A SOLID ROCKET BOOSTER/J-2S LAUNCHER**
Joseph R. Fragola, PE, Blake F. Putney, Jr., Joseph W. Minarick III, and **Benjamin J. Franzini,** *SAIC*
This paper documents the process implemented and the results obtained from a top-down evaluation of the new crew SRB/J-2S launcher and how risk assessment has driven the design.

13A3 RELIABILITY ANALYSIS OF PHASED-MISSION SYSTEMS: A PRACTICAL APPROACH
Dr. Mansoor Alam, *University of Toledo,* **Min Song,** *Old Dominion University,* **Steven L. Hester,** *Alternative Systems, Inc.* and **Thomas A. Seliga,** *Volpe National Transportation Center*
This paper presents a novel and simple approach to reliability analysis of phased-mission systems.

13A4 SAFE CREW LAUNCH BY DESIGN
Joseph R. Fragola, PE, *SAIC*
This paper addresses the issues that limit crew safety during launch and ascent to low Earth orbit (LEO) and suggests guidelines that might provide designers with guidance on how to design reliability and safety into new or existing launcher designs.

Session 13B **Pacific Salon C**
PROCESS IMPROVEMENTS AND NEW TECHNIQUES IN SYSTEMS SAFETY
Moderator: Patrick M. Dallosta, *NTVI Federal, Inc.*
Traditional Safety analyses are now enhanced by the "rebirth" of Fault Tree Analysis (FTA), Failure Modes, Effects and Criticality Analysis (FMECA), Root Cause Analysis (RCA), and Reliability Centered Maintenance (RCM). This session presents applications of these and other techniques that integrate the safety and engineering disciplines. The result is a more effective capability to mitigate risk and improve performance.

13B1 MAINTENANCE MANAGEMENT SYSTEM REVIEW IN A SAFETY MANAGEMENT SYSTEM APPLIED TO A MAJOR HAZARD PLANT
Dr. Mario Tucci, *Universita degli Studi di Firenze,* **Ing. Irene Cappelli, Ing. Francesca Tocchi,** and **Ing. Corso Piazzini,** *Universita di Firenze*
A case study of the maintenance management of a high risk power plant based on Reliability Centered Maintenance, Safety and Fault Tree Analyses.

13B2 ACCIDENT CAUSE ANALYSIS OF COMPLEX SYSTEMS BASED ON SAFETY CONTROL FUNCTIONS
Dr. Takehisa Kohda and **Yohei Takagi,** *Kyoto University*
A discussion of the use of accident modeling to determine the cause and impact of the loss of safety controls.

13B3 INCORPORATING DEMAND MODELS INTO THE ASSESSMENT OF SAFETY SYSTEM PERFORMANCE
Dr. Julia V. Bukowski, *Villanova University*
A discussion of the impact of undetected failures on safety inspection requirements and utility of performance indicators in assessing the probability of a catastrophic event.

13B4 A NOVEL SAFETY-CRITICAL SYSTEM MODELING APPROACH: TERNARY DECISION DIAGRAM
Yangyang Yu and **Dr. Barry W. Johnson,** *University of Virginia*
The use of parameterized modeling to measure, predict and survive faults and failures for a safety-critical computer system, where safety is a higher priority than reliability.

13B5 SAFETY ASSESSMENT FOR SAFETY-CRITICAL SYSTEMS INCLUDING PHYSICAL FAULTS AND DESIGN FAULTS
Yangyang Yu and **Dr. Barry W. Johnson,** *University of Virginia*
A study of both design related faults and wear out failures and the assessment processes used to identify, mitigate and eliminate them.

Tutorial 13C **SPECIAL TOPIC** **Pacific Salon E/F**
RISK MANAGEMENT
Richard B. Jones, *HSB Solomon Associates*
The Concept of risk is presented and then applied to develop practical risk management tools that can be applied to real-life decision making situations.

Session 13D **Pacific Salon D**
COMPONENT RELIABILITY ENHANCEMENT TECHNIQUES
Moderator: Dr. Vasiliy V. Krivtsov, *Ford Motor Company*
Session discusses modern reliability engineering methods and practices helping to assess and improve component-level reliability

13D1 INTEGRATED MODELING FOR FAULT-TOLERANT SENSOR NETWORK RELIABILITY AND SECURITY
Dr. Liudong Xing and **Howard E. Michel,** *University of Massachusetts*
We consider the reliability and security modeling of wireless sensor networks (WSN) in this paper. WSN are being used in increasingly diverse application areas such as healthcare, military, environmental, home, etc. Because sensor nodes are limited in power, memory, computational and communication capabilities, and because they usually operate in unattended and harsh environments, sensor nodes are prone to failures.

13D2 LOW-COST HARDENING TECHNIQUES FOR CMOS LOGIC
Ghazanfar Asadi and **Masoud Hashempour,** *Northeastern University*
Hardening techniques are becoming crucial for next generation combinational circuits. In this work, we characterize the soft-error susceptibility of 0.25µ MOSIS library against different charges of SEUs (0.1pC, 0.2pC, 0.3pC, and 0.4pC). Then, we explore the effect of different implementations of a logic function on the soft-error susceptibility of the circuit. We also exploit the asymmetric signal probabilities of the internal nodes to put selective protection on pull-up and pull-down networks.

13D3 AUTOMOTIVE COMPONENT RELIABILITY: SHOULD IT BE MEASURED IN TIME, MILEAGE OR BOTH?
Dr. Vasiliy V. Krivtsov and **Dr. Michael Frankstein,** *Ford Motor Company*
This paper is a sequel to our work published in 2003 RAMS Transactions (V. Krivtsov and M. Frankstein, "Nonparametric Estimation of Marginal Failure Distributions from Dually Censored Automotive Data", Proc. Annual Reliability and Maintainability Symposiumh, 2003, pp. 86-89.) While the main point of the previous paper was to show that there is a difference between marginal in time and mileage distributions estimated from the same data set. The intent of this paper is to discuss how this difference may be explained.

13D4 A PRACTICAL MTBF ESTIMATE FOR PCB DESIGN CONSIDERING COMPONENT AND NON-COMPONENT FAILURES
Dr. Tongdan Jin, Teradyne Inc. and **Peng Wang,** *United Technologies Research Center*
For printed circuit board (PCB) design, mean-time-between-failures (MTBF) is an important design specification for new product lines. Quite often a new product fails to be launched for high volume manufacturing due to low reliability. Most MTBF prediction models for PCB are usually developed based on component failure rates and the bill of materials (BOM) of the board. The resulting estimation is quite optimistic in general and a PCB could fail in field operation.

13D5 IMPROVING THE OPERATIONAL RELIABILITY OF A COMPLEX SYSTEM BY DE-MYSTIFYING COMPONENT INTE
Ian James, *Goodrich Engine Control Systems*
In today's aircraft systems there are high levels of integration, particularly with regard to the maintenance system. Whereas, in the past, troubleshooting of aircraft systems relied heavily upon expertise in a particular area, there are now trends towards a more centralized system, involving the use of the aircraft computers. This increased integration necessitates a change in the skills required for effective troubleshooting.

10:15 AM — 12:15 PM, THURSDAY

Session 14A **Pacific Salon A/B**

MANAGING RISK IN AEROSPACE BUSINESS PRACTICES
Moderator: Dr. Robert J. Loomis Jr., *NASA*
Mission Success, Flight Safety, Consumer Confidence and National Objectives all rely on the identification and mitigation of risk through innovative management and engineering processes and programs. This session presents new methods of identifying critical system components, assessing their performance in phased missions, and predicting aircraft aging based on material properties.

14A1 A BAYESIAN APPROACH TO RELIABILITY DEMONSTRATION FOR AEROSPACE SYSTEMS
Scott William Yates and **Dr. Ali Mosleh,** *University of Maryland*
A case study in the reduction of support costs through the assessment of system reliability characteristics prior to acceptance.

14A2 AN INTEGRATED APPROACH FOR THE PROBABILISTIC RISK ASSESSMENT OF THE MARS RELAY NETWORK
Dr. Leila Meshkat and **Andre R. Girerd,** *Jet Propulsion Laboratory*
This paper describes the analysis conducted to assess the capability of the Mars relay network based on the integration of the individual reliability assessments of several spacecraft.

14A3 A SIMULATION APPROACH TO RISK-INFORMED ANALYSIS OF COMPLEX DYNAMIC SYSTEMS USED IN PLANETARY MISSIONS
Mohammadreza Azarkhail, *University of Maryland,* and **Dr. Homayoon Dezfuli,** *NASA Headquarters*
A discussion of the use of dynamic failure modeling to predict the reliability and safety of propulsion systems and their sensitivity to changes in demand over mission phases.

14A4 IDENTIFYING THE MAJOR CONTRIBUTIONS TO RISK IN PHASED MISSIONS
Professor John Andrews and **Rachel La Band,** *Loughborough University*
The paper presents a method of implementing a cost effective risk reduction process for a system operating in a phased mission scenario.

14A5 AIRFRAME INTEGRITY BASED ON BAYESIAN APPROACH
Jose L. Hurtado, *University of Maryland* and **Dr. Paul C. Hoffman,** *NAVAIRSYSCOM*
A mathematical method of assessing the variability of material properties for their impact on fatigue cracking is presented.

Session 14B **Pacific Salon C**

DESIGNING RELIABILITY INTO LARGE SCALE PETROCHEMICAL SYSTEMS - INVITED SESSION
Moderator: Aron Brall, *SRS Technologies*
The petrochemical industry has taken great strides in marrying the systems engineering process with sound product assurance discipline - see how reliability and maintainability is applied to generate real results via design and analysis.

14B1 AVAILABILITY OPTIMIZATION USING SPARES MODELING AND THE SIX SIGMA PROCESS
James W. Owens, *The Dow Chemical Company*
At Dow Chemical Company, Six Sigma has become the norm in driving process improvement. This paper will detail how six sigma, reliability modeling and simulation, and the optimization of spares have driven value in the productivity improvement equation.

14B2 FROM REQUIREMENTS DEVELOPMENT TO VERIFICATION - DESIGNING RELIABILITY INTO A LARGE SCALE CHEMICAL MANUFACTURING SYSTEM
Author S. Miller, *The Dow Chemical Company*
Culture change has come slowly in the chemical industry, but with the advent of six sigma and other improvement methodologies, designing reliability in to chemical manufacturing systems has become much more important. A roadmap is identified along with results.

14B3 **THE MONTE CARLO METHOD AND THE OPTIMIZATION OF SPARE PARTS IN COMPLEX REALISTIC SCENARIOS**

Dr. Arie Dubi, *Ben Gurion University*

Optimizing resources, spare parts, and repair teams, etc. in a complex or simple logistic system is a major problem in systems engineering. The dependence of the system's performance on spare parts is discussed and the hybrid method of combining analytic approximations and Monte Carlo "learning" calculations is explained.

Tutorial 14C **INTERMEDIATE** **Pacific Salon E/F**

FAULT TREE ANALYSIS USING BINARY DECISION DIAGRAMS

Professor John Andrews, *Loughborough University*

The advances in fault tree analysis using Binary Decision Diagram (BDD) offers advantages in accuracy and efficiency. This tutorial first discusses and compares various forms for expressing system failure logic. BDD technique is the main focus of this tutorial. In particular, how to convert a fault tree diagram into a BDD form and how to obtain top event probability will be demonstrated.

Session 14D **Pacific Salon D**

RELIABILITY-DRIVEN PRODUCT DESIGN

Moderator: Kellie Schneider, *University of Arkansas*

Papers in this session examine the importance of identifying and managing reliability requirements early in the design process. The role of reliability and risk analysis are explore in the systems engineering design process.

14D1 **WE NEED TO CHANGE THE WAY RMA DOES BUSINESS!**

Joseph A. Dzekevich, *Raytheon Company*

In this paper, the author suggest that specifying good design process in the Statement of Work is an effective alternative to specifying only MTBF as a performance measure.

14D2 **USING RMA MONTE CARLO ANALYSIS AS PART OF THE SYSTEMS ENGINEERING DESIGN PROCESS**

Joseph A. Dzekevich and **Jaime Franqui,** *Raytheon*

A detailed case study is examined in which RMA (Reliability, Maintainability, and Availability) engineering in a systems engineering design role had a very positive effect on the program.

14D3 **INTEGRATED APPROACH TO RELIABILITY-BASED DESIGN OF FUTURE ELECTRONICS SYSTEMS**

Loren Nasser, Dr. Robert G. Tryon, and **Richard J. Rudy,** *VEXTEC Consultant*

This paper discusses the development of a new electronics design framework. Validation work that conveys the realities of this framework is discussed as well as future plans for implementation of this framework for automotive design.

14D4 **RELIABILITY RELATED CONCEPT COMPARISON AND DERIVATION OF A RISK ANALYSIS IN EARLY DESIGN STAGES**

Dipl.-Ing. Peter Muller, *University of Stuttgart,* **Dipl.-Ing. Karsten Pickard,** *Institute of Machine Components,* and **Dr-Ing. Bernd Bertsche,** *University of Stuttgart*

This paper illustrates the concept comparison method which offers the opportunity for a systematic, comprehensive and reusable procedure to validate different design concepts in the early stages of design.

RAMS DISCIPLINE TRACKS

While all sessions will contain elements of interest for the majority of participants, special disciplines are emphasized in individual sessions. If your profession tends to specialize in the areas listed in the first column below, we recommend you attend the sessions listed opposite your specialty.

PARTICIPANT SPECIALITY	MONDAY			TUESDAY				WEDNESDAY				THURSDAY	
	8:00 - 10:00 AM	10:15 - 12:15 PM	2:45 -4:45 PM	8:00 - 10:00 AM	10:15 - 12:15 PM	1:30 - 3:30 PM	3:45 - 5:45 PM	8:00 - 10:00 AM	10:15 - 12:15 PM	1:30 - 3:30 PM	3:45 - 5:45 PM	8:00 - 10:00 AM	10:15 - 12:15 PM
Education	All	All	All	All	All	All	All	All	All	All	All	All	All
Computer Aided Engineering			4D	5E	6D				All	11B			
Data Analysis	1B, 1D	2A	4A, 4B	5C, 5E	6B,6C, 6E	7B, 7D, 7E		9A, 9C, 9E	All	11A, 11C 11E	12E		14A
Design/Development	1B, 1D	2A	4A	5A, 5C, 5E	6A, 6C, 6D 6E	7C	8D, 8E	9E	All	11B, 11C 11D	12A, 12C 12D	13A, 13C 13D	14A, 14B 14C, 14D
Logistics	1A, 1B	2C	4C	5C, 5E	6C	7A, 7C, 7E	8A, 8B	9B, 9D	All	11B, 11C	12A	13B	14B
Maintainability	1C, 1B, 1D		4C	5C		7A, 7C, 7E	8B, 8D	9D	All	11B, 11C	12A, 12B 12D	13B	
Maintenance	1C	2C	4A,4C	5D		7A, 7E	8B, 8D	9D	All	11B, 11C	12A, 12B	13B	
Management	1A,1C	2A	4A	5A, 5D	6A, 6C, 6E	7A, 7C	8A, 8B, 8E	9B, 9D	All	11B, 11D 11E	12A, 12B 12D	13B, 13C	14A, 14D
Product Quality		2A	4A, 4B	5A, 5B, 5D	6C		8A, 8D	9B, 9E	All		12B	13D	14A, 14B 14D
Reliability	1A, 1B, 1D	2C	4A, 4B	5B, 5E	6B, 6C, 6E	7A, 7C, 7D 7E	8A, 8B, 8E	9A, 9B, 9E	All	11D	12A, 12C 12E	13D	14B, 14C
Safety		2C		5D					All	11E	12C, 12D	13A, 13B 13C	14A, 14C
Simulation			4D	5E					All				
Software			4B	5B				9E	All				
Statistics & Probability	1B, 1C	2A, 2C	4A, 4B, 4C	5B, 5C, 5E	6A, 6B, 6C 6E	7B, 7C, 7D 7E	8B, 8C, 8E	9A, 9C, 9E	All	11A, 11D	12B, 12D 12E		14B
Systems Engineering	1A, 1C	2A, 2C	4A, 4B, 4C	5B, 5D, 5E	6B, 6C, 6E	7A, 7E	8B, 8D	9B, 9D, 9E	All	11E	12A, 12C 12E	13A, 13B 13C	14A, 14C 14D
Test and Evaluation	1B, 1D	2C	4A, 4B	5C	6B, 6C, 6E	7B, 7E	8C, 8D	9A, 9E	All	11A	12A, 12C 12S	13B	14B

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Wednesday, January 25, 10:15 - 12:15 PM

Please use the following space to provide your question(s) for the panel and return it to the *RAMS* Registration Desk no later than 9:00 A.M., Wednesday, January 25.

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Name and Affiliation (Optional)

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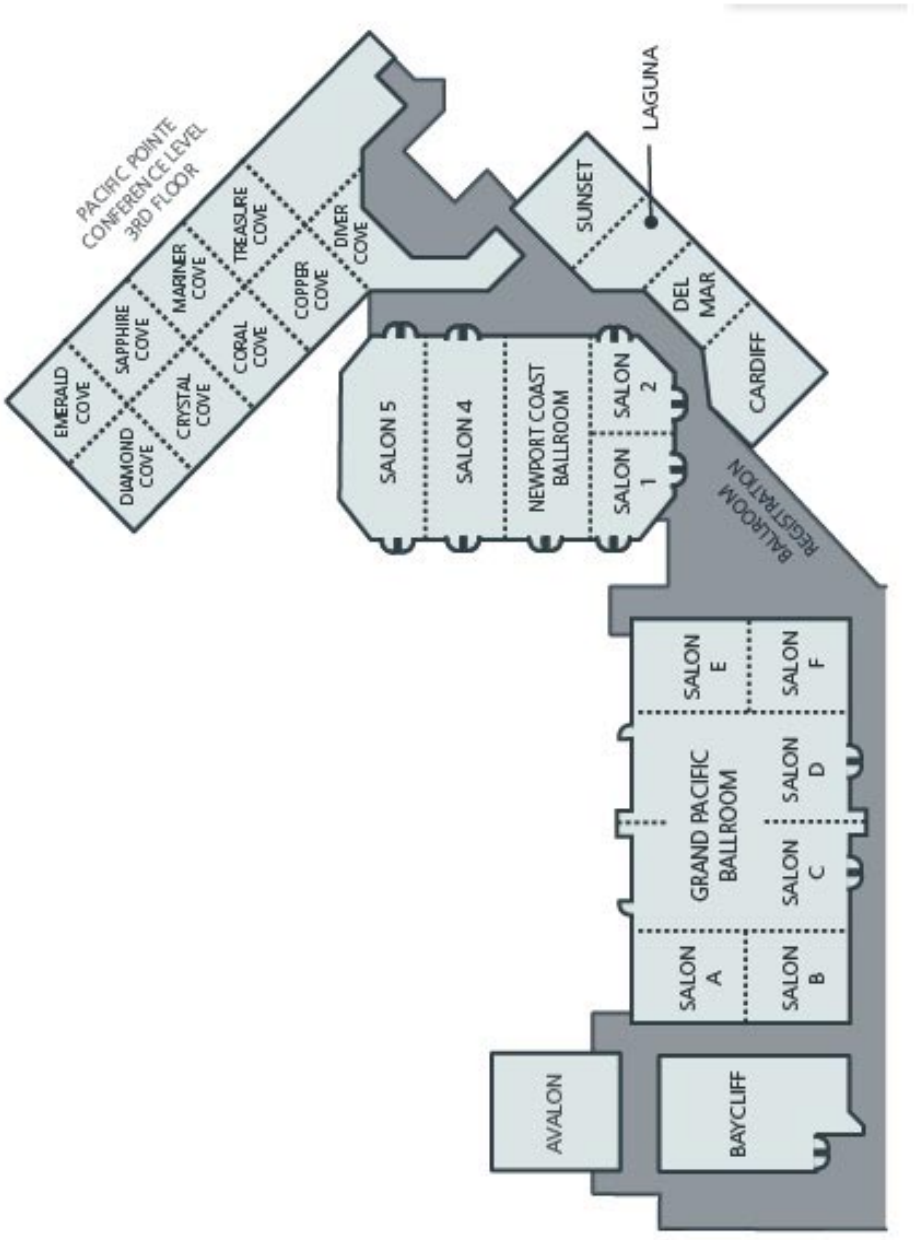

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